Public Understanding of Science: The Royal Society Reports

"Would the world be a better, or even a different, place if the public understood more of the scope and the limitations, the findings and the methods of science?" The British Royal Society answers a resounding "yes" to that question and, in a new report, describes how public understanding might be improved and who should be directly involved in that effort.

In April 1983, the Royal Society Council appointed an ad hoc group, chaired by Walter F. Bodmer.* The group's terms of reference included:

(i) to review the nature and extent of public understanding of science and technology in the United Kingdom and to assess the adequacy of such understanding for an advanced industrialized democracy;

(ii) to review the mechanisms for effecting the public understanding of science and technology; and

(iii) to consider the constraints upon the processes of communication and how they might best be overcome.

The Working Group defined "science" broadly and took "public" to mean the predominately non-scientific public. They also construed "understanding" to include not just knowledge of facts, but also comprehension of the nature of scientific activity and inquiry. Clearly, they wrote, the level of understanding needed will depend on the purpose to which that information will be put, as well as on an individual's occupation and responsibility. Voters exercising their civic responsibility need one level or type of comprehension; people in industry or government who are responsible for major decision-making may need another. Sometimes their requirements are, of course, the same.

The report examines the evidence for what those basic levels of understanding are and should be, and considers the various ways for improving both formal and informal education in science.

The Public Understanding of Science (The Royal Society, 1985), is obtainable from the Publications Sales Department, The Royal Society, 6 Carlton House Terrace, London SW1Y 5AG, price £6.90.

The Working Group's Summary*

"Science and technology play a major role in most aspects of our daily lives both at home and at work. Our industry and thus our national prosperity depend on them. Almost all public policy issues have scientific and technological implications. Public decision-makers, whether Parliamentarians, civil servants, leaders of commerce or industry or voters in a democratic society, therefore need to understand the scientific basis of their decisions. So, too, do private individuals going about their daily lives. Everybody needs some understanding of science, its accomplishments and its limitations, whether or not they are themselves scientists or engineers. Improving that understanding is not a luxury: it is a

* Members of the Working Group were R. E. Artus, Sir David Attenborough, R. J. Blin-Stoyle, Sir Kenneth Durham, Sir John Mason, M. J. Savory, Lord Swann, Dorothy Wedderburn, Dame Margaret Weston, and John M. Ziman.

* This section reprints verbatim the Working Group's summary ("Science Is for Everybody") provided with the report.

Science, Technology, & Human Values, Volume 11, Issue 3, pp. 53–60 (Summer 1986) CCC /0162-2439/86/03053-08$04.00

vital investment in the future well-being of our society.

"This is the main message of the report on the public understanding of science, published by the Royal Society. Achieving a substantial improvement in the public understanding of science (defined broadly to include technology, engineering, mathematics and medicine) will depend especially on the scientific community itself recognizing its responsibilities to the public. It will also require the educational system and the mass media to rise to the challenge of teaching and presenting science to the public on a broader front, and the decision-makers to provide the necessary resources.

"Transport and disposal of radioactive waste, the control of environmental pollution, energy sources, or public health measures such as vaccination, have obvious and major scientific features. But the scientific basis of such issues, not surprisingly, is often overshadowed by other factors such as economic constraints (e.g., in setting farm production quotas), environmental worries (e.g., about the exploitation of natural resources), ethical concerns (e.g., about the use of animal experiments in medical research), social factors (e.g., those arising from the introduction of new technologies in the manufacturing or service industries), local aesthetic, social and commercial issues (e.g., in decisions about land use), diplomatic factors (e.g., in the provision of overseas aid and technical assistance), fears about the power of large organizations (e.g., in decisions to build nuclear power stations), or the defence of individual freedom (e.g., in the fluoridation of water supplies).

"Responsible decision-making requires an understanding of all the aspects of a given issue, including the science, and depends on achieving an appropriate balance between them. Balance cannot be achieved if a key component of an issue is ignored or misunderstood. That is why a better understanding of science and technology by Parliamentarians, local government, senior civil servants and leaders of industry is so important.

"In a democracy public opinion is a major influence in the decision-making process. Individual citizens, no less than the decision-makers, therefore need to recognize and understand the scientific aspects of public issues.

"Strong economies almost all depend on a strong manufacturing industry based on the application of fast-developing science and technology. New technologies, such as those involved in electronics, synthetic materials, telecommunications or biotechnology, have developed from basic science. Their successful exploitation is the task of the professional engineer or scientist. But it also requires those responsible for the nation's industries to be aware of science and technology so that they can recognize their potential value and accept the opportunities they generate. Hostility or indifference to science and technology, whether by shopfloor workers, by middle or senior industrial management or by investors, weakens the nation's industry. Such negative attitudes appear to be commoner in Britain than in our major industrial competitors. The United Kingdom would be more competitive if those who held positions of responsibility had a better understanding of what science and technology can achieve.

"Many personal decisions, for example about diet, vaccination, personal hygiene or safety at home and at work, should be helped by some understanding of the underlying science. Greater familiarity with the nature and findings of science will also help the individual to resist pseudo-scientific information and to sift the plausible from the implausible. The major findings of science, for example about cosmology or evolution, profoundly influence the way we think about ourselves and are an important part of our culture. Without some understanding of science, an individual is cut off from much of the richness of contemporary human thought.

What Is Scientific Understanding?

"A proper science education at school must provide the basis for an adequate understanding of science. Further information and education throughout life builds on this foundation. Understanding includes not just the facts of science, but also the method and its limitations as well as an appreciation of the practical and social implications. Lack of unanimity among scientists on an issue such as diet and heart disease must not be misinterpreted as a failure of the scientific method. But neither should quick technological "fixes" for problems such as acid rain be accepted before they have been properly investigated scientifically. Science for all should provide the basis for dealing with these issues. Decision-makers calling for scientific advice need to know the limitations of scientific investigation. Managers in government and industry, when developing technological policies, need to understand the relation between fundamental and strategic scientific research. Consumers can only evaluate claims for "scientifically proven" products if they know some science. Individuals need to understand the nature of risks when told about the potential hazards of cancer-causing chemicals, cigarette smoking or vaccination.

"A basic understanding of statistics, including the nature of risks, uncertainty and variability, and an ability to assimilate numerical data are an essential part of understanding science. There is no such thing as absolute safety or zero risk. Risks and their costs always have to be balanced and that must be understood.

The Way Ahead

"There is no doubt that the public is interested in science, and rightly so. This is shown by many attitude surveys, by audiences of up to 10 million for science programmes on television, and by the many millions that each year visit the Science and Natural History museums. Scientists, educators, politicians, civil servants and industrialists must accept the challenge of improving public understanding of science at all levels from the individual to the Government minister, and from the shop floor to the boardroom.

The scientific community

"Professional scientists have mostly left it to others to communicate science to the public. This attitude is no longer appropriate, if indeed it ever was. Scientists must learn to communicate with the public, be willing to do so, and indeed consider it their duty to do so.

"All scientists therefore need to learn about the media and their constraints, and to learn how to explain science simply, without jargon and without being condescending. Formal courses on the media and practical experience in explaining science to the lay public should be provided throughout the formal scientific education.

"The scientific community is spread among many organizations, including learned societies, professional institutions, polytechnics, universities and their departments, research councils, central and local government departments, private foundations and charities, and industrial and commercial organizations. Each of these should assess their potential for improving public understanding of science on a broad front, for example by providing training on communication and greater understanding of the media, arranging non-specialist lectures and demonstrations, publishing science newsletters, organizing scientific competitions for younger people, providing briefings for journalists, and generally by improving their public relations. Scientific organizations also need to develop mechanisms for ensuring that Parliamentarians are aware of the scientific aspects of public issues.

The mass media

"Television, radio, newspapers, magazines and popular books can all have a major influence on the public understanding of science. The quality of science programmes and features on television and radio is generally high in Britain. There is, however, scope for more science in the media, especially in the daily newspapers. Feature articles are particularly valuable because science as such is rarely news. Biographical and dramatic approaches help to show science as a human activity in a historical context.

"Many general interest programmes, not labelled as science, nevertheless have a significant scientific content. This applies especially to news and current affairs. There is a strong case for including more science in such general programmes and so for improving the contact between scientists and journalists as a whole.

Education

"The formal education system, including schools, universities and polytechnics, is ultimately the most important determinant of public understanding of science, but takes a long time to change. This increases the urgency for providing a broadly based science education at school for all to the age of 16, and for providing the resources to make this possible.

"Much greater priority should in particular be given to science courses in all primary schools, taught by appropriately qualified teachers.

"Some understanding of statistics, including the ideas of risk, uncertainty, ratios and variability, which are intrinsic to the scientific method and are a major factor in understanding many personal and public issues, should be a goal of all science courses.

"No pupil at school should be allowed to study only arts, or only science, even after the age of 16. A revised system allowing a broader range of subjects to be taken at a somewhat lower level than A-level is urgently needed. University teachers, especially of science subjects, must be persuaded of the overall value to our society of a broader post-16 curriculum. Universities should also find some way for undergraduates to benefit from the proximity in the same institution of experts in subjects outside their own courses of study.

"Arts subjects in university are generally considered appropriate for a wide range of careers that have little to do with the disciplines studied, whereas science subjects tend to be regarded as the prelude to a career in science. Consequently, relatively few people trained in science enter generalist careers in, for example, administration or the Civil Service. In 1984 only 13% of applicants (and 14% of successful applicants) for the Administration Trainee grade in the Civil Service had degrees in science or technology. Yet a good science course provides an excellent training in the skills needed in such careers. Science students and their teachers should recognize the wider market for their skills.

Government

"The Parliamentary and Scientific Committee, which brings together Parliamentarians and a wide range of scientists, could become a more effective forum for improving scientific understanding in Parliament. More meetings could be arranged, at short notice if necessary, to discuss the scientific aspects of issues about to be debated in Parliament. The Government publishes many reports that deal with scientific and technical issues. Popular versions of such reports could be made widely available as a matter of course.

Industry

"Scientists involved in research in industry should be encouraged to take wider and earlier opportunities in management positions, helped by appropriate management training. More scientists with relevant experience should be brought from academic institutions directly into senior management or into non-executive directorships. Larger science-based companies should be encouraged to require middle management to have appropriate formal scientific qualifications.

"Industry should also promote general activities such as lectures, seminar briefings, competitions and especially school visits. Companies should inform the public, particularly in their own community, about the scientific and technological bases of their activities, so that there is a better understanding of both the benefits and the problems of what they are doing.

The Royal Society

"The Royal Society, as the foremost learned scientific society in the country, should take a lead in stimulating scientists to take on the responsibility of improving public understanding of science. This could and should become one of its major activities. Specific initiatives should include briefing seminars and an information service for journalists, help and advice to other scientific institutions on issues such as communication of science to the public, media contact and public relations, and improved contact with Parliamentarians and others at a high level in government and industry.

"Many conclusions and recommendations similar to those in the Royal Society report have been discussed before, by the Royal Society and by others. If they had been put into practice there would have been no need for the present report. Improving the general level of public understanding of science is now an urgent task for the wellbeing of the country. It requires concerted action from many sections of society, including most importantly the scientific community itself.

Museums

"Recent initiatives in developing fully interactive exhibits and mounting temporary exhibitions on the scientific aspects of current affairs are of considerable value and deserve strong support."

Some Remarks from the Main Report

On Understanding Risk and Uncertainty

In Chapter 2, the Working Group writes:

> In a democracy public opinion is a major influence in the decision-making process. It is therefore important that individual citizens, as well as the decision-makers, recognize and understand the scientific aspects of public issues. To decide between the competing claims of vocal interest groups concerned about controversial issues such as 'acid rain', nuclear power, *in vitro* fertilization or animal experimentation, the individual needs to know some of the factual background and to be able to assess the quality of the evidence being presented. Wider understanding of the scientific aspects of a given issue will not automatically lead to a consensus about the best answer, but it will at least lead to more informed, and therefore better, decision-making. [Paragraph 2.7, p. 10]

One of the factors necessary to foster this wider understanding is good communication of the nature of risks and uncertainty. Whether an individual is making an everyday decision or voting in a national referendum on a science-based issue, understanding of the risks is necessary to informed action.

> Decisions on nuclear power stations or on medical screening programmes or seat belts or motorway speed limits all involve a balancing of risks, taking into account a variety of social, political, economic and scientific factors. Some sections of the public seem to demand that an industrial procedure or a nuclear power plant is free from risk. But there is no such thing as a zero risk, only a balancing of risks and their costs. A 1 : 100,000 chance of deformity from a whooping-cough vaccine causes considerable concern, yet parents who for genetic reasons are known to be at risk may often be willing to accept a 1 : 10 risk of having an abnormal child. There are many examples of issues where to play our role as citizens in a democratic society, or to take in advice that may have a major influence on our personal lives, an understanding of risks and, more generally, of the interpretation of numbers (i.e., statistics) is important. [Paragraph 2.10, p. 10]

On Scientists' Responsibility for Communication

But whose responsibility is it to communicate about such risks? Should it be left to the media i.e. to specialist science writers—or to government decisionmakers directly involved in each issue? The Royal Society report takes an enlightened approach in Chapter 6 by placing the major responsibility on the shoulders of the organized scientific community.

Scientists are notably reluctant to take on this role—and in some cases, the report notes, have been ill-equipped to do so:

> Two recurring themes of the previous chapter on the media were, on the one hand, the scientist's mistrust, lack of understanding and often unwillingness and inability to communicate adequately with the journalist, and on the other hand the importance of a good rapport between scientist and journalist if science is to be properly and adequately represented in the media. This same good rapport is also needed with Parliament, the Civil Service, and industry. [Paragraph 6.1, p. 24]

Perhaps because the Working Group was composed primarily of scientists, they take an authoritative stance in saying what they believe should be done: ". . . our most direct and urgent message is for the scientists—learn to communicate with the public, be willing to do so, indeed consider it your duty to do so" [Paragraph 6.2, p. 24].

"Professional scientists," they write, have often "delegated to others the task of communicating science to the public." Such outstanding British popularizers as T. H. Huxley, John Tyndall, Arthur Eddington, James H. Jeans, J. D. Bernal, Lancelot Hogben, J. B. S. Haldane, and Jacob Bronowski, however, were "unusual and their activities were by no means always properly appreciated by the scientific community."

> Indeed, within the scientific community there is still often a stigma associated with being involved with the media. There is now, however, a substantial body of professional journalists and writers . . . whose job it is to interpret science and scientists to the lay public. It is tempting, therefore, for professional scientists to conclude that the business of communicating with the lay public may safely be left to others. After all, scientific research is what scientists are good at, what they are paid to do and what should have first claim on their attention. Communicating sci-

> ence to the lay public is not easy and, it may be thought, should be left to those whose full-time job it is. [Paragraph 6.2, p. 24]

However, the Working Group argues, "such an attitude is no longer appropriate, and probably never was," for the scientific community "is necessarily the ultimate source of scientific understanding."

> . . . scientists as a whole must recognize that they have a serious responsibility to speak to the lay public. Scientists are also democratically accountable to those who support scientific training and research through public taxation. If the public is not told about the scientific research it supports, it is unlikely to worry if the level of support is reduced. It is clearly a part of each scientist's professional responsibility to promote the public understanding of science. [Paragraph 6.3, p. 24]

How to do this? The vision of thousands of scientists knocking on doors, or appearing on television talk shows, is clearly not what the Group's members intended. Instead, they urge an important change in the science curriculum, adding communications skills to the requirements of scientists' training:

> The first requirement is to learn how to communicate science effectively to a lay public. Some aspects of this can and should be taught formally to all professional scientists. The language used must be simple and free of jargon, without being condescending. Everyday analogies can be very helpful in explaining complicated scientific concepts. [Paragraph 6.4, p. 24]

They also recognize that training without opportunities for experience will be useless:

> Fluent communication of science to the lay person, however, ultimately depends on experience. Opportunities should therefore be provided throughout all formal education for gaining such experience. A useful step in this direction would be, as suggested by others, for every Ph.D. candidate to explain the essential background and nature of his or her thesis work to a lay audience, for example in the form of a short written article. [Paragraph 6.4, p. 24]

On Informal Learning: Adult Education Programs and Museums

Other opportunities for improving this wider understanding of science come through existing programs in adult education. Programs in educational associations, evening schools, and university extramural departments attract thousands of adults every year, to study a variety of subjects, including science.

> [These classes] tend to be organized differently from the formal education system, and some of them offer scope for introducing motivated adults to the non-technical aspects of science. They can contribute very usefully to improving public understanding of science. We recommend that those responsible for organizing adult education provide a larger number of courses dealing with general aspects of science. [Paragraph 7.4, p. 27]

The report unfortunately gives only a few paragraphs to the use of museums. A major informal mechanism for public communication, museums of science reach millions of people every year. Ranging from small city museums of local history (usually including archeology) to the great national museums, these showcases of science provide a widely-varied mix of education with entertainment: "In recent years the educational function has received a more explicit emphasis and a number of multi-media displays have been designed to engage visitors interests and illustrate basic scientific principles" [p. 28]. The Report describes one such place, currently under development in France:

> Another related development is one currently planned for the Parc de la Villette in Paris. Here a small area will be set aside for exhibits explaining the scientific principles behind some issue of current public concern. Each exhibit will be shown for one month only, so as to maintain topicality. These exhibits are a sort of three-dimensional equivalent of a feature article in a monthly magazine or a journalists' briefing seminar. Museums in [the United Kingdom] should consider such schemes as a contribution to more scientifically informed discussion about public issues. [Paragraph 7.5, p. 28]

Shopfloor to Boardroom: On Industry's Role in Communication

It is somewhat unusual for such a report to pay close attention to not only the effects of industrial advertising but also the level of scientific understanding *within* industry, to what the report calls "the need for appropriate scientific understanding at all levels from the shopfloor to the boardroom" [p. 29]. This inclusion may have been affected, of course, by concerns for British high-technology industry, but the message is one that is international in import.

They call for "immediate action" within science-based companies, especially with regard to in-service training of all employees:

> In-service training should help to improve the overall level of appropriate scientific knowledge. It needs to impart a broad understanding of the principles behind a company's technology, the limits and uncertainties of the science and technology, and their social significance, rather than simply to transfer sufficient knowledge to enable staff to operate existing machinery. This applies to all levels of staff from senior manager to operative, though obviously tailored to suit their different needs. If a firm's own employees have some understanding of what underlies its operation, they are also able to stimulate better informed discussion about that firm in its own neighbourhood. [Paragraph 8.2, p. 29]

They also encourage more public outreach by industry, more corporate sponsorship of science communication to the public, and cooperative programs with scientific societies:

> Industry, furthermore, often has the resources to promote activities such as lectures, competitions and seminar briefings or to sponsor science programmes on the media. This support should be encouraged, because it is likely to provide the best hope for adequate resources for improving the public understanding of science, which should benefit industry as much as it does other sectors of society.
>
> Industry, learned societies and other scientific institutions should cooperate in promoting activities aimed at improving public understanding of science. Such cooperation would improve not only the actual implementation of the initiatives but also the mutual understanding of the parties involved, which should help them to present a more rounded view of science. Some industrial firms make considerable efforts to explain what science is, for example through advertisements that are genuinely informative about the nature and outcome of scientific research, through films, publications and exhibitions. There is scope for closer cooperation between learned scientific societies and industry in promoting such activities. [Paragraphs 8.6–8.7, p. 29]

Industry has a social responsibility, the Working Group argues, to educate the public about the scientific and technological bases of its activities.

> Firms have a major task in educating the public about the scientific and technological bases of their activities. It is neither possible nor desirable for them to try to circumvent public opinion by ignoring it—rumours and half-truths are likely to circulate and are bound to misinform. At both the national and, particularly, the local level, firms should take all reasonable steps to ensure that the public can understand both the benefits and the problems of what they are doing. This includes providing the public with sufficient scientific and technological background information to help them balance the benefits and problems of different options. [Paragraph 8.8, p. 29]

They can do this through corporate publications, "informative" advertisements, and community open houses, but whatever the forum, this approach requires not only "the skill to communicate at the right level and imagination in finding ways of putting information across," but also "a willingness to be open, for example, about risks."

> A more open policy of this sort is in the long-term interests of both industry and the public. Many firms do of course already make considerable efforts in this direction, but there is much more that could be done. It is a question not of selling industry but of improving public understanding of the scientific and technological (and other) aspects of policy issues affecting industry. [Paragraph 8.8, p. 30]

The article on research regulation published elsewhere in this issue of *STHV** should reinforce

* See Sheldon Krimsky, "Research under Community Standards: Three Case Studies," *Science, Technology, & Human Values*, Volume 11, Number 3 (Summer 1986). For more on the topic of the link between public regulation of research and public understanding, see Office of Technology Assessment, "The Regulatory Environment for Science," OTA-TM-SET-34 (Washington, DC: February 1986).

this encouragement for greater industry openness and communication of science-related issues.

The Message: Willingness to Learn

In summary, the Royal Society's Working Group on the Public Understanding of Science acknowledges that, although some of the mechanisms for improving understanding offer short-term effectiveness, many others will yield results only in the long term. To that end, they close with a statement certain to be heard again: ". . . our most direct and urgent message must be to the scientists themselves: Learn to communicate with the public, be willing to do so and consider it your duty to do so" [p. 36].